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ABSTRACT

An investigation derived from the logico-structural theory of world view was conducted for the purpose of examining the relationship between science interest and variations in the causal universal within college students' world views. This required the development of a special pen-and-paper instrument for detecting worldview variations in the causal universal. The instrument was based on the assumption that when a student is faced with an unfamiliar phenomenon, he or she is more likely to accept an explanation that is more consistent with his or her world view than an explanation of the phenomenon that is less consistent. The test involved making a choice between explanations that were scientifically-more and scientifically-less compatible. The test, along with a measure of science interest, was given to 120 college freshmen. The test, alone, was given to a group of professional scientists. The results suggested that there was considerable worldview variation among the students and that this variation was related to science interest. It was also found that even the students with science interests were less likely to choose a scientifically-more compatible explanation than were the professional scientists. It was concluded that the investigation lends corroboration to the logico-structural theory of world view. (Author/CW)

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Distinguishing Science-Related Variations in the Causal Universal of College Students' World Views

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Abstract

An investigation derived from the logico-structural theory of world view was conducted for the purpose of examining the relationship between science interest and variations in the Casual universal within college students' world views. This required the development of a special pen-and-paper instrument for detecting worldview variations in the Causal universal. The instrument was based on the assumption that when a student is faced with an unfamiliar phenomenon, he or she is more likely to accept an explanation that is more consistent with his or her world view than an explanation of the phenomenon that is less consistent. The test involved making a choice between explanations that were scientifically-more and scientifically-less compatible. The test along with a measure of science interest was given to a 120 college freshman. The test alone was given to a group of professional scientists. The results suggested that there was considerable worldview variation among the students and that this variation was related to science interest. It was also found that even the students with science interests were less likely to choose a scientifically-more compatible explanation than were the professional scientists. It was concluded that the investigation lends corroboration to the logico-structural theory of world view and provides a further rational for pursuit of research in this area.

The sensitivity and richness of the logico-structural worldview model (Cobern, 1989; Kearney, 1984) allows rational justification for the expectation of worldview variation in the typical school classroom, quite opposite of what one would expect working under a thematic worldview framework (e.g. Pepper, 1942; Kilbourn, 1984). Of course this then raises the question of empirical evidence. And if the evidence is forthcoming the question then becomes, do these variations actually exert a significant influence on science achievement and attitude as predicted by the theory? This paper reports on the development of an instrument designed for the purpose of detecting the hypothesized worldview variations and reports data collected in response for these questions. The instrument is the Test of Preferred Explanations (TOPE) which is intended to distinguish science related variations in the Causal universal of college students' world views. The purpose of this study was first to test for the existence of theory predicted worldview variation; and second to examine the relationship between worldview variation and science interest.

Theoretical Framework, Limitations and Hypotheses

The logico-structural model of world view is a composite of seven universals: Self, NonSelf, Classification, Relationship, Causality, Time and Space. Logically related presuppositions make up the content of these structurally related universals. The composite forms the epistemological foundation upon which cognitive and perceptual frameworks are built. In constructivist

theory these structures are a crucial factor in the assimilation of new knowledge (Novak, 1982) and in forming attitudes and interests. It follows then that world view as the foundation for cognitive structure will have a significant influence on learning and attitude development. Where students are of diverse cultural backgrounds there is a *prima facie* case for considering world view as a factor in the processes of education. However the logico-structural theory of world view suggests that even in situations usually considered culturally uniform there is likely to be some worldview variation precisely because world view is a composite of seven constructs. In any given educational setting some presuppositions will be shared by many students, others by only a few. The investigation reported here was designed to test for this theory predicted variation among students. The second question addressed in the investigation is the relationship between worldview variation and interest in science.

Linking worldview variation to science interest requires that the investigator have some knowledge of how the presuppositions and attributes in various universals correspond to the nature of science. The investigator, in other words, must have some knowledge of what constitutes a scientifically compatible world view. The status of worldview research is not such that this information is readily available. Therefore the focus of this investigation had to be of limited scope. Because there exists a greater understanding of scientific causality, the

investigation explored variation only within the Causal universal. The investigation began with the development of (TOPE) which was subsequently used to assess science compatibility in the Causal universal. Three null hypotheses were tested:

> There is no significant difference between the TOPE scores of scientists and the TOPE scores of students with high science interest.
>
> There is no significant difference between the TOPE scores of scientists and the TOPE scores of students with low science interest.
>
> There is no significant difference between the TOPE scores of students with high science interest and the TOPE scores of students with low science interest.

Instrument Development

Undoubtedly, there are many ways one could use to distinguish worldview variations among students. In this investigation the approach was to develop a paper-and-pen instrument that could be given to a large number of students in a short period of time. The instrument is intended to be a preliminary discriminating device used prior to more incisive, investigative techniques, probably techniques of the ethnographic type, perhaps using an Interview Vee (Ault, Novak & Gowin, 1984). The content of the instrument derives from the contention that a scientifically compatible world view must include presuppositions in the Causal universal that are appropriate to scientific explanation.

The primary problematic feature of any instrument designed to discriminate among students according to worldview variations is that the instrument itself must not be a test of scientific

knowledge. As explained in an earlier paper on worldview theory in science education research (Cobern, 1989), being ignorant of scientific concepts does not necessarily indicate a worldview variation. With regard to distinguishing variations in the Causal universal, this can be avoided by making the following assumption:

> When a student is faced with an unfamiliar phenomenon, he or she is more likely to accept an explanation that is more consistent with his or her world view than an explanation of the phenomenon that is less consistent.

If one presents a student with an unfamiliar phenomenon and two explanations, one cast in a scientific style and the other not, one would expect students with scientifically compatible world views to choose the first explanation more frequently than students with variant world views. This suggests that an effective instrument could be constructed with *unfamiliar phenomena* as items.

Instrument Development

The construction of TOPE began with the identification of unfamiliar phenomena to be used in the items. Unfortunately, one can never be sure who is familiar with what. An alternative procedure which avoids this problem is to create descriptions of fictitious or quasi-fictitious phenomena. For the current study 28 such descriptions were created. The original instrument used these plus three more descriptions based on factual, but obscure phenomena. The test instructions indicated that the items did

not necessarily contain factual information, and therefore the test is not a test of knowledge.

The investigator assumed that presuppositions amenable to scientific explanation are present in a student's world view if a student frequently chooses explanations that are scientifically compatible. Thus a scientifically compatible explanation was needed for each item. Obviously the explanations for the fictitious phenomena would be fictitious. The explanations for the obscure phenomena items also needed to be fictitious in order to avoid confounding affects of students who might happen to be knowledgeable about the obscure phenomena. The criteria for designing a fictitious, but scientifically compatible explanation came primarily from Braithwaite's book *Scientific Explanations* and to a lesser extent Aicken's *The Nature of Science*.

According to Braithwaite, an explanation and hypothesis are virtually the same thing. To be acceptable in science they must be empirical and above all, testable. A scientific explanation or hypothesis always involves natural causes and tends to be mechanistic and reductionistic. The key terms are:

1. natural
2. rational
3. mechanistic/reductionistic
4. hypothetical/deductive
5. experimental
6. epistemologically dynamic/tentative.

Any scientific explanation is also a part of a theoretical structure or system composed of many explanations, generally on different levels of explanatory power. Scientific explanations

are not given in isolation (Martin, 1972), however with the exception of one TOPE item which relates experimentation to theory, all of the items contain ad hoc explanations. The notion that explanations should be related to other explanations in an explanatory system is not unique to scientific thinking however, and thus was not included as a criterion for the items in this instrument.

The foil in each item was an explanation designed to be scientifically-less compatible or simply scientifically unacceptable. The criteria for composing such explanations were basically the opposite of the above terms with the exception of *rational*. An attempt was made to write reasonable explanations that were holistic rather than reductionistic, non-testable and non-mechanistic. The 31 items in the original instrument were primarily written by the investigator. Two physicists and a mathematician offered useful expert, editorial advice plus suggestions for items.

The Selection of Items

Having compiled and edited 31 items, the next step was to test their discriminating power. This was done by giving the instrument to subjects identified as having a strong or weak scientifically-oriented world view, and retaining only the items that discriminated between the two groups. Scientists and engineers comprised the former group. The group assumed to have

weak, scientifically oriented world views were primarily non-science students at the University of Sokoto, Nigeria. The second assumption was deemed sound because these were students raised in a non-scientific, non-technological society who at the university level still had professed little interest in science and had no recent science instruction. The second group also included female secretaries at two American colleges who professed little science interest and who had no recent science instruction. The demographics of this group were such that one would expect them to have much less of a scientific orientation than a group of scientists (Vetter & Babco, 1987).

The test was constructed in three, 31 item formats. In format A, each item contained a phenomenon description followed by two explanations of opposing style. One explanation was cast in a scientifically-more compatible style and the other in a scientifically-less compatible style. The adjectives *scientifically-more* and *scientifically-less* were chosen with purpose. None of the explanations is scientifically compatible because all are fabrications. However, it can be argued that when the explanations are considered in isolation some are more compatible with science than others.

In formats B and C, the descriptions were followed by one explanation and a five-point scale of *acceptability*. The instructions to participants called the instrument a survey, rather than a test, and indicated that the instrument did not call for

technically *correct* responses. In Format A, the subjects were to choose the one explanation of the two that they found more acceptable. In Formats B and C, they were to indicate on the scale how acceptable they found the single explanation. At no point was any indication given that this instrument was a part of research in science education.

The item selection basis for inclusion in the final instrument was a 0.4 minimum difference between the science and non-science groups. For example, if on an item 80 percent of the science professors chose the scientifically-more compatible explanation but only 40 percent of the students chose this explanation, then the item was retained. The decision to use a 0.4 difference was based on Hopkins' and Stanley's (1981) discussion of item discriminating power.

Following this guideline, the initial analysis of the data led to the retention of 12 items. Four other items initially predicted to be good discriminators, in fact did not get the anticipated response from the scientists and engineers. Subsequently, these four items were given to a professional scientist who had not participated in the initial study. Based on his comments one of the four items was dropped. The other three were modified and retained. The final instrument contained seventeen items. Fifteen of these came from format A, and two from formats B and C. The complete instrument is published elsewhere (Cobern, 1988).

The process of establishing item validity was concurrent with item development and selection. To be explicit, validity in the study was approached first as a matter of content. The items were judged to have content validity because they were based on the work of an expert, i.e., Braithwaite. Furthermore, content validity was affirmed by having the items reviewed by a panel of scientists and science educators. In their opinion the items contained accurate examples of scientifically-more and scientifically-less acceptable explanations. Secondly, construct validity was affirmed by choosing only those items that discriminated between known groups.

Research Method

The investigation was conducted with college freshmen instead of secondary students both as a matter of logistical convenience, and to minimize confounding factors such as reading ability. Therefore, TOPE was given to 120 freshmen at Austin College in the Fall of 1987. These students were enrolled in a required freshman course and represented just under half of the freshman class. The students were given a list of college discipline areas including science. As an indicator of science interest the students were asked to check the one or two areas that most interested them and the one or two of least interest. The two questions were combined and scored as 1 for science being checked on the first list but not the second, 0.5 for science not being checked on either list, or 0 for science being checked on

the second list but not the first. The students were thus divided into three groups, those with science interest, those with some science interest, and those with little or no science interest.

Copies of TOPE were also sent to 200 scientists randomly selected from the American Scientific Affiliation directory. Of these 88 usable, completed tests were returned (44%). The theory predicted that the mean TOPE scores of the student groups and of the professional scientists would be significantly different, and that TOPE scores would increase with interest. The null hypotheses were tested using a oneway ANOVA procedure and T-tests between cell means (Walonick 1986). The p value for rejection was set at 0.01. The results are given in Tables 1, 2, and 3.

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INSERT TABLES 1,2, & 3

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Discussion of Results

Based on the student scores, the test-retest reliability was calculated to be 0.81. The three null hypotheses were rejected at $p =< 0.01$. The expected order of results was confirmed. The mean score for professional scientists was highest followed by the mean score of students with high science interest. The students with low science interest had the lowest mean score on TOPE. Given the cursory gauge of science interest the positive results are encouraging. One would expect to find even greater

The Group Means of
Scientists and Students

Cell Definition	N	Mean	SD
Students w/ No sci interest	35 (16.8%)	9.74	2.43
Students w/ Some sci interest	36 (17.3%)	10.38	1.74
Students w/ Sci interest	49 (23.6%)	11.40	2.08
Professionals	88 (42.3%)	12.36	2.06
	208 (100.0%)		

TABLE 1

Anova Summary Table

Source of Variation	DF	Sum of Squares	Mean Squares	F	Significance Level
Sci Interest	3	214.14	71.38	16.45	0.00
Error	204	885.34	4.34		
Total	207	1099.48			

Table 2

T-Test Between Cell Means
(Values of p are for a two-tailed test)

No sci interest vs. Some sci interest	N/S
No sci interest vs. Sci Interest	t = 3.59 p = 0.00
No sci interest vs. Professionals	t = 6.28 p = 0.00
Some sci interest vs. Sci interest	N/S
Some sci interest vs. Professionals	t = 4.81 p = 0.00
Sci interest vs. Professionals	t = 2.59 p = 0.01

TABLE 3

differences with science interest measured by a more sophisticated instrument.

The group mean for scientists is lower than expected. One factor to consider is that the scientists in the study were largely from liberal arts colleges. As such they may be more open to different explanation styles than research scientists at research universities. Another possibility is that the lower than anticipated scores indicate a lack of instrument sensitivity. Redoing the study using a group of research scientists at research universities would help to answer the question. It must be remembered however that the theory does not demand that scientists always choose scientifically compatible explanations. The Causal universal is influenced by the presuppositions that form the other universals, particularly those in Classification and the NonSelf. In other words, even scientists are likely to have more than one notion of causality.

Conclusion

The objectives of the investigation were achieved. The very fact that TOPE was successfully developed based on differences among people corroborates the worldview theory inference of worldview variation. Secondly, the analysis of TOPE scores by science interest among students and by the comparison of student TOPE scores with the TOPE scores of professional scientists corroborates the inference that worldview variation can significantly influence science interest. The investigation thus

lends corroboration to the logico-structural theory of world view and provides a further rational for pursuit of research in this area.

This investigation was very much a pilot project in that it was a first attempt at research derived from worldview theory based on the Kearney logico-structural model. Attempts now should be made to replicate these results. That effort can be facilitated by the further refinement of TOPE and by conducting research with more sophisticated measures of science interest and attitudes. If at some point an alternative measure of variation in the Causal universal can be developed, use of a multitrait-multimethod matrix for establishing construct validity may become possible (Campbell & Fiske, 1959; Kerlinger, 1986). This would allow a more powerful test of the validity of worldview theory.

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_____ GENDER: M F

NAME

If the following were your only choices for a college major, which one or two areas would you most likely choose as a major? Check one or two areas.

_____ art/music

_____ science

_____ English

_____ political science

_____ history

_____ business/economics

If the following were your only choices for a college major, which one or two areas would you be least likely to choose as a major? Check one or two areas.

_____ art/music

_____ science

_____ English

_____ political science

_____ history

_____ business/economics

For the purpose of my research I would like to compare your scores on this instrument with your SAT/ACT scores and Myers-Briggs results. The information will be kept strictly confidential. If I may have your permission to obtain your SAT/ACT and Myers-Briggs results from the College files, please sign here:

SURVEY OF PREFERRED EXPLANATIONS

Instructions:

In the following pages you will find a series of paragraphs each describing a fictitious event or phenomenon. Each paragraph is followed by either one or two explanations of what is in the paragraph. Do not think of the explanations as either correct or incorrect. In fact none of the explanations are necessarily correct. This is a survey of the kind of explanations people find more convincing when they hear about something of which they know very little.

Use the answer sheet for recording your answers. For the items with two explanations choose "A" or "B" according to which explanation you would be more willing to accept. For the items with one explanation choose a rank according to how acceptable you find the given explanation.

ANSWER SHEET

Circle only one answer per item. Avoid choosing "?" as much as possible. Use it only when you absolutely cannot decide between "A" and "B".

1.	1	2	3	4	5
2.	1	2	3	4	5
3.	A	?	B		
4.	A	?	B		
5.	A	?	B		
6.	A	?	B		
7.	A	?	B		
8.	A	?	B		
9.	A	?	B		
10.	A	?	B		
11.	A	?	B		
12.	A	?	B		
13.	A	?	B		
14.	A	?	B		
15.	A	?	B		
16.	A	?	B		
17.	A	?	B		

ITEM 1

Reports from a recent space flight indicate a new material has been identified in outer space. Although insensitive to the presence of ordinary matter, when approached by a human being it glows brightly in a variety of colors.

It has long been suspected from other evidence that human beings give rise to psychic emmanations, but the main difficulty has always been the development of a suitable detector for this influence. This new material appears to be an ideal detector for it is sensitive to human proximity as well as operating over a wide range of personality types.

How acceptable is this explanation to you? Select the appropriate rank below:

1. completely acceptable with no objections or reservations.
2. very acceptable with few objections or reservations.
3. acceptable but with some objections or reservations.
4. somewhat acceptable but with several objections or reservations.
5. not acceptable.

Item 2

Recently astronomers have observed an increase in radio wave activity of particular frequency from a particular sector in the sky. This observation has caused a stir and a great deal of speculation as to its explanations. So far most astronomers accept the following explanation:

> Man has often doubted that he was alone in this vast universe. These radio waves might well be radio signals from some far civilization upon which we have stumbled or indeed they may even be meant for us.

How acceptable is this explanation to you? Select the appropriate rank below:

1. completely acceptable with no objections or reservations.
2. very acceptable with few objections or reservations.
3. acceptable but with some objections or reservations.
4. somewhat acceptable but with several objections or reservations.
5. not acceptable.

Item 3

Some people were observing a demonstration that involved a miniature red train car, a bit of track, and a tunnel. When the demonstrator pushed the train car into the tunnel a blue car came out the opposite side. When the demonstrator pushed the blue car back into the tunnel, the red car reappeared out the other side. People suspected there were really two cars, originally the blue one being hidden by the tunnel. To test this idea they listened carefully when the red car was pushed into the tunnel feeling sure that they would hear it knocking the blue car out the opposite side. Try as they might, they could hear no sound of a collision. The people then fell into two groups over the matter. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

Some people found the demonstration intriguing and amusing. They considered the demonstrator to be a kind of magician who was proving that the hand really is quicker than the eye.

Explanation B:

Other people recalled that like-poles of magnets repel each other. So perhaps there were two cars each with a magnet. Like-poles faced each other so that one car entering the tunnel drove the other out without the two ever touching.

If you absolutely have no preference for one over the other, mark "?".

Item 4

There once was a woman who, to put it mildly, drank a great deal. Every day after work she would begin going from bar to bar until late in the night. Hardly a day would pass that she did not end in a state of intoxication. People said this was not even the worst of her moral degeneracy, but that she was as well a cruel and spiteful woman. She seemed to delight in unkindness. One morning she did not come to work. Later it was learned that she died the night before of a heart attack. Her colleagues at work had two opinions about her fate. Which one would you be more willing to accept? Choose "A" or "B".

Explanation A:

As the doctors said, she died of a heart attack. She undoubtedly put too much physical strain on her system and her heart finally gave way.

Explanation B:

She was a young woman who should have had many years ahead of her. She was, however, decadent and mean, and an untimely death was the consequence.

If you absolutely have no preference for one over the other, mark "?".

ITEM 5

Occasionally when entering a room for the first time a person gets the distinct impression that he has been there before. This impression can be very strong and disturbing, and all the more because one is sure that he has not ever seen the room before. There seems to be two reasonable explanations for this phenomenon. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

This is an example of deja vu which is something almost all of us experience from time to time. It is remembering a place you have never been to before or an object or person you have never seen before. This phenomenon is a reminder of the vast complexity of the human mind, a complexity of which we understand very little. What we understand least is the capacity of the mind to perceive things outside the range of our basic physical senses.

Explanation B:

The human brain is a complex electro-chemical computer. Although for the most part it functions faultlessly, there are occasional lapses. The above is such a case. After the first glimpse of the room, there is an instantaneous functional lapse and recovery. The lapse separates the initial glimpse from the current perception of the room. The result is that the initial glimpse becomes like a memory. A person is deceived into thinking that he has seen the room before.

If you absolutely have no preference for one over the other, mark "?".

ITEM 6

Two men became tired of working for their living so they decided to rob a bank to make themselves rich. They took guns, went to a local bank and demanded all the money. An alert policeman saw what was happening and intervened. The robbers fearing capture fired their guns. In the confusion they managed to escape in a stolen car leaving behind several injured and dying people. By this time the robbers were panic stricken and raced down the road at a very high speed. On a curve the driver lost control of the car and both of them died in a ghastly accident. Among the people who read about this incident in the newspapers there seemed to be two feelings about why these robbers died. Which explanation below do you find more acceptable? Choose "A" or "B".

Explanation A:

Why did these men die? We may be glad that they did die being so evil. The "how" however, is more simple. They poorly planned their evil deed. Had they carefully thought it all out ahead of time they either would have abandoned the idea or would have developed a much less reckless plan.

Explanation B:

Sometimes we look around and see the evil that people get away with, and we think to ourselves, "There is no justice." But often there is justice and here is a good example. These men willfully decided to do evil. Why did these two die? It was the just price of their evil.

If you absolutely have no preference for one over the other, mark "?".

ITEM 7

In the past when a person's heart stopped beating he was declared dead. Now medical doctors have the technology to restart a person's heart if they act quickly enough and thus to bring him back to life. A curious result of this is that we are now receiving interesting reports from these patients who have "died" but have been saved by this new technology. These reports are about the experiences these people have had during the minutes when their hearts were not beating. They claim that during that time they experienced the afterlife, that is the life that many people believe to be waiting for a person after he dies. There have been two reactions to these claims. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The dreams of a sleeping man are due to various electro-chemical processes in the brain. When a man's heart stops beating these brain processes do not immediately stop as well. His mind may still be dreaming since it takes time for this electro-chemical activity to cease. If the doctors are able to revive a man's heart, then when he regains consciousness what he remembers are only dreams like any other.

Explanation B:

We may say that a man has died when his heart stops beating. What we really should say is that his body has died. The spirit of the man still lives just as the philosophers have so often taught. The reports from these people who have died and then been revived give us the first empirical evidence that the spirit of a man does not die with his body.

If you absolutely have no preference for one over the other, mark "?".

ITEM 8

In many areas of the world today the health of the people is looked after by traditional and herbal medicine practitioners. These traditional physicians practice a healing art based on generations of accumulated knowledge. In spite of this, the modern study of medicine does not include any areas of this traditional knowledge. Recently doctors concerned about this issue have divided into pro and con groups. Which position below would you be more willing to accept? Choose "A" or "B".

A: PRO-POSITION

The study of modern medicine is the study of western medicine. This should tip us off to the real reason behind the resistance to the scientific study of traditional herbal medicine. It is pure and simply western chauvinism. From the scientific point of view there is no reason for not carefully researching well-documented traditional cures. The findings would benefit all of mankind; and in addition there would be a greater appreciation of the traditions of non-western peoples.

B: CON-POSITION

Modern experimental medicine has been successful largely because it is directed by rational theory. The theoretical structure of a science tells the investigator which avenues of experiments are most likely to be profitable, thus avoiding many dead-ends. Since there is no such structure in traditional medicine a researcher would have to follow dozens, even hundreds of vague accounts of "cures that work." Such ad hoc experimenting is wasteful and inefficient. It is for this same reason that researchers do not investigate the "home cures" that are used by so many families.

If you absolutely have no preference for one over the other, mark "?".

ITEM 9

A startling discovery has recently been made amongst a pre-modern group of people in a remote region of the Amazon Basin. An anthropologist living with these people for a year noted that the council of elders had a perfect record on predicting rainy days. Out of 365 days there were 109 days on which rain began to fall. All of these days were correctly predicted two to four days in advance. For the same period of time the government meteorological forecasts were much less accurate. The elders based their predictions upon the pattern made by dried chicken bones which they would cast a specific number of times each day. The elder's accuracy impressed the scientist but he was skeptical that the bones had much to do with it. He therefore got the elders to cooperate in a number of experiments by which he hoped to determine the real nature of their predictions. These experiments confirmed none of his hypotheses, all were rejected. In the end he was convinced that the predictions must indeed rest upon the chicken bones. Later the anthropologist reported his findings at a symposium; and although his peers agreed with his conclusions they disagreed in their reasons. Which side do you find more acceptable? Choose "A" or "B".

Side A:

One side noted that pre-modern people, although pre-modern are still clever. They skillfully put to use the collective observations and knowledge of their ancestors, as in this case where a people are able to predict weather by observing bone patterns. Modern people are surprised by this achievement only because they think of the pre-modern person as naive and unintelligent.

Side B:

The other side noted that chemists have long known that dry bones absorb moisture from the air. The amount of "bounciness" in a bone likely depends on how much moisture has been absorbed; thus there is a possible link between bone-bounciness and weather conditions.

If you absolutely have no preference for one over the other, mark "?".

ITEM 10

Pea seeds when passed through a magnetic field germinate faster than seeds which are not passed through a magnetic field. There appears to be two logical explanations for this. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The magnetic field has an effect on the pea seed chromosomes. This results in faster cell division due to the pre-alignment of the chromosomes by the magnetic field. The seeds therefore germinate quicker.

Explanation B:

After fertilization there is a principle of life which begins to drive the growth process. At an early stage that principle can be stimulated and quickened by many outside forces such as a magnetic field.

If you absolutely have no preference for one over the other, mark "?".

ITEM 11

When plant seeds are grown in small pots it is possible to quicken their growth rate by periodically shaking the pots. This "shaking effect" is poorly understood but there are two schools of thought on the matter. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The roots of plants use up first the nutrients in the soil which are closest. The result is that the amount of soil nutrients increases with distance from the roots. Shaking stirs up the soil and helps bring richer but distant soil into contact with the roots.

Explanation B:

All living things benefit from an occasional but gentle stirring up of their environment, and even of themselves. It gets the juices, fluids and chemicals moving and flowing. It provides fresh air and removes the stale. It encourages, one might say, the processes of life.

If you absolutely have no preference for one over the other, mark "?".

ITEM 12

Bird migrations are an interesting phenomenon. For instance some geese can fly thousands and thousands of kilometers from one point on the earth to another never getting lost. This remarkable feat of navigation is of great interest to biologists and also controversial. There are two much debated explanations. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

Some biologists view bird navigation as a kind of natural movement. For instance, humans can both walk and crawl; but they always walk because that is what is natural for them to do. It is possible for geese to fly in the wrong direction but that would be like humans crawling. They do not do it because it is unnatural.

Explanation B:

Some biologists are quite convinced that wind currents act like Coriolis forces on the birds. The geese are sensitive to very slight variations in wind force and direction. By instinct they react to these variations and thus maintain their course.

If you absolutely have no preference for one over the other, mark "?".

ITEM 13

Is it logically possible for a system to explain itself? It appears to be a circular dilemma since to explain itself a system can only explain in terms of itself. For instance is it possible to know how the brain really works since any theory put forward by scientists is a product of the human brain? . The dilemma seems very discouraging yet many scientists are undetered. Should we be optimistic or pessimistic about this kind of research? Which of the positions below would you be more willing to accept? Choose "A" or "B".

Position A:

The key to understanding any system, no matter how complicated, is in its parts. The parts are usually less complicated than the whole. By examining and experimenting with the parts we eventually will learn enough about the whole brain to enable us to restore all neurological disorders.

Position B:

Science has enjoyed great progress in understanding natural phenomena and scientists as a result have come to take progress as a scientific right. They have lost sight of the fact that all human endeavors including progress are limited and unending progress is not to be expected. If neuro-scientists were to remember that then their present viewpoint on the human brain would certainly be more humble.

If you absolutely have no preference for one over the other, mark "?".

ITEM 14

People often wonder when confronted by the human-like characteristics of chimpanzees why they have not evolved the ability for language and speech. Opinion on this issue is divided. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

The thoughts and emotions of a chimp are simple, lacking complexity, and can be communicated to another chimp by simple means, e.g. gestures. On the other hand an elaborate capacity for speech is required by humans because of their equally elaborate structures of thought and emotion. Simple means of communication would just not be sufficient.

Explanation B:

Appearance can be deceiving as in the case of human-like characteristics of chimpanzees. The primary distinction between other animals and human beings is the "humanity" of man which is composed of such abilities as speech and rational thought. Without "humanity" man would indeed be just another animal.

If you absolutely have no preference for one over the other, mark "?".

ITEM 15

A goal that geologists have long had is to acquire enough knowledge about earthquakes so that they can be anticipated hours or even days in advance. Recently it was discovered that many animals can do just that. The geologists are still unsure about just how a particular animal senses a quake coming but there are two theories. Which theory below would you be more willing to accept? Choose "A" or "B".

Theory A:

There are many things in the environment that animals sense such as danger or changes in the weather. This is an ability that modern people have lost due to their remoteness from nature and reliance upon technology.

Theory B:

It has now been learned that there are slight almost imperceptible pre-tremors that come hours, sometimes days before a major quake. These pre-tremors are noticed by animals particularly grazing animals, which then become quite nervous.

If you absolutely have no preference for one over the other, mark "?".

ITEM 16

Astronomers have found that certain planetary bodies appear to deviate slightly from their calculated position in space. The deviation is extremely small. Everyone working in this field agrees:

a. that the deviation exists (i.e. it is real), and
b. that Relativity Theory offers the most likely explanation.

When asked why they supported this explanation workers were found to be divided. Which explanation below would you be more willing to accept? Choose "A" or "B".

Explanation A:

It is difficult to make accurate measurements and existing experimental evidence lends only weak support for the theory. Nevertheless, the evidence gives better support to this theory than to any other.

Explanation B:

The explanation was published by one of the most distinguished scientists of the 20th century. There is no doubt that he knows more than anyone else in the world about this particular phenomenon.

If you absolutely have no preference for one over the other, mark "?".

ITEM 17

A physicist at a well known university was conducting a unique set of experiments. He was interested in the effect of electrical discharges on the growth rates of a particular type of tree. The methodology was simple. He administered electrical shocks to one set of trees but not to a second. Over a period of several months he measured and compared the growth rates of the two groups. The scientist's work caused a stir among his colleagues because he admittedly had no theoretical framework for his research. There were two basic opinions about this kind of experimentation. Which opinion below would you be more willing to accept? Choose "A" or "B".

Opinion A:

The highly theoretical nature of physics provides an ample number of research problems for experimental work. Theory guided research is more efficient because there is a greater chance of success. This man has picked an idea out of thin air and pursued it for no other reason than idle curiosity.

Opinion B:

This man should not be criticized for his unique albeit different research problem. All too often progress in many fields is thwarted by over-conservatism and rigid adherence to theory. Independence from theory should be encouraged so that more discoveries can be made and the understanding of nature increased.

If you absolutely have no preference for one over the other, mark "?".